48/79
PR7: Y5 DEY 2

COMMERCIAL IN CONFIDENCE

WAVE ENERGY STUDY

NEL OSCILLATING WATER COLUMN BOTTOM STANDING DEVICE PRELIMINARY STUDY

ADDENDUM

for

Department of Energy

Report No. PR7: Y5 DEY 2 September 1979

NATIONAL ENGINEERING LABORATORY

Department of Industry

This report is issued as part of the contract under which the work has been carried out for the sponsor. Any restrictions in the contract on the release of information to third parties apply to this report.

Department of Industry
NATIONAL ENGINEERING LABORATORY
East Kilbride Glasgow Scotland
Telex 77588 Telephone 0355 2 (East Kilbride) 20222

COMMERCIAL - IN - CONFIDENCE

WAVE ENERGY STUDY
NEL OSCILLATING WATER COLUMN

BOTTOM STANDING DEVICE
PRELIMINARY STUDY

ADDENDUM
September, 1979

Executive Summary

The original report dated May 1979 has been revised to take account of newly available data. Output predictions have been revised and agreed with Rendel Palmer and Tritton. New costs have been calculated which show a 66% reduction when compared with the floating design. The target of 10p/kWh appears to be within reach.

Roxburgh and Partners
Mirren House
6 Maxwell Street
Paisley
Renfrewshire PA3 2AB

National Engineering Laboratory
East Kilbride
Glasgow G75 0QU

Addendum to Preliminary Study

Following from discussion of the Bottom Standing Device Preliminary Study Report (NEL Report No. 48/79 PR7:Y5 DEY2) at a NEL Technical Review Meeting held at East Kilbride on 31st July, 1979 it was agreed that values used for the site correction factor (f site) and the directionality correction factor (fd) for the bottom standing device should be modified to take account of the latest information available.

It was also agreed that the power chain efficiency for the bottom standing device would be reviewed by NEL and the result passed to Rendel Palmer and Tritton for reassessment. A preliminary review has been made and has been assessed by Rendel Palmer and Tritton, who have agreed that the values obtained from this review are satisfactory for the purposes of the addendum.

Accordingly the power delivered predictions are re-presented incorporating a revised value for fd for the Floating 78 Reference Design and incorporating revised values for f site, fd, η d and η p for the bottom standing device. The original Table 3 is now expanded to Table 3.1 giving the values and predictions used by Rendel Palmer and Tritton in their presentation at the Heathrow Wavepower Workshop, November, 1978, Table 3.2 giving the output comparisions for the floating and bottom standing NEL devices using the revised values as above and Table 3.3 giving notes to Table 3.2.

Based on the revised output figures, the costings have been recalculated and are presented again in Tables 4.1 and 4.2. A range of unit costs are given for both the floating and bottom standing devices using the upper and lower bound 95% confidence limit values for the power delivered. It must be emphasised that the capital and maintenance costs have been prepared solely to allow comparison between the two devices. However they are considered to be reasonably indicative of comtemporary actual costs.

Table 3.1 Output Predictions for 78 Reference Designs

Figures for Devices 1 - 3 from RPT presentation notes for Heathrow Wavepower Workshop, November 1978.

	KEY: (HIGH ESTIMATE) MOST LIKELY (LOW ESTIMATE)	Annual Apparent Power at S Uist Buoy	Shallow Water Correction (As Captured)	Site Correction (Energy Loss and Shielding)	Direction-ality Correction	Device Capture Efficiency		Power Chain		Power Delivered to Perth
						Based on PM Spectra	Digital Spectrum Correction	Effici-ency	Reliab-ility	UPPER BOUND 95% CONFIDENCE LIMIT MEAN LOWER BOUND 95% CONFIDENCE LIMIT
No.	DEVICE	kW/m	fsw	f site	fd	η d	f digital	η p	fr	kW/m
1	NEL 78 Reference Design	(46)		(1.15)	(0.75)	(0.44)		(0.55)	(0.92)	(5.7)
		42.3	1.13	1.1	0.65	0.39	0.92	0.37	0.87	4.2
	Floating with Hydraulics	(39)		(1.0)	(0.50)	(0.34)		(0.33)	(0.80)	(3.1)
2	HRS	(46)		(1.0)	(0.75)	(0.45)		(0.60)	(0.95)	(4.9)
		42.3	1.13	0.9	0.65	0.33	0.92	0.41	0.92	3.2
		(39)		(0.7)	(0.50)	(0.21)		(0.35)	(0.83)	(1.9)
3	OPTIMISTIC BEST DEVICE Scenario 2	42.3	1.13	1.1	0.7	0.6	0.92	0.7	0.95	13.5

Table 3.2

Output Comparisons for NEL Devices

Figures prepared with advice and assistance from ETSU and RPT

	Key: COLS 1 - 8 (HIGH ESTIMATE) MOST LIKELY (LOW ESTIMATE) [AVERAGE VALUE]	(1) Annual Apparent Power At S Uist Buoy	(2) Shallow Water Correction (As Captured)	(3) Site Correction (Energy Loss and Shielding)	(4) Direction-ality Correction	(5) Device Capture Efficiency	(6)	(7) Power	(8) Chain	(9) Power Delivered To Perth UPPER BOUND 95% CONFIDENCE LIMIT MEAN LOWER BOUND 95% CONFIDENCE LIMIT
						Based on PM Spectra	Digital Spectrum Correction	Effic-iency	Reliab-ility	
No.	DEVICE	kW/m	fsw	f site	fd	η d	f digital	η p	fr	kW/m
1A	NEL Floating 78 Reference Design RPT Report with Hydraulics	(46.0) 42.3 (39.0) 	 1.13 [1.13]	(1.15) 1.1 (1.0) [1.083]	 0.78 [0.78]	(0.44) 0.39 (0.34) [0.39]	 0.92 [0.92]	(0.55) 0.37 (0.33) [0.417]	(0.92) 0.87 (0.80) [0.863]	(6.8) 5.2 (4.0)
4A	NEL Bottom Standing Device Team No Hydraulics	(46.0) 42.3 (39.0) 	 1.13 [1.13]	(0.75) 0.61 (0.45) [0.603]	 0.78 [0.78]	(0.82) 0.73 (0.64) [0.73]	 0.92 [0.92]	(0.78) 0.61 (0.55) [0.65]	(0.95) 0.92 (0.83) [0.90]	(11.5) 8.8 (6.5)

Also see notes on Table 3.3

Table 3.3

Notes to Table 3.2

1. Directionality correction factor (Column 4) amended to ETSU value as given at NEL Technical Review (TR) Meeting No.2 on 31st July 1979 for devices facing in optimum direction.

2. Site correction factor for bottom standing devices taken as agreed at NEL TR Meeting No.2:

   (High Estimate) - 0.65 x value for floating device
   Most Likely - 0.55 x ditto
   (Low Estimate) - 0.45 x ditto

   These figures represent the best available estimate at this time (August 1979).

3 Row 1A - Power chain efficiency taken from RPT Wavepower Workshop Presentation Notes November 78 (as Table 3.1).

   Rows 4A - Power chain efficiency taken as that expected from a scheme without hydraulic interconnection of the turbines.

Table 4.1

Estimated Cost of Bottom Standing Device

1. CAPITAL COSTS	Floating	Bottom Standing	
	£ per m	£ per m	
Body of Structure	86200	62500	C_S
M & E Plant	25800	25000	$C_{M/C}$
Tow and Install	5200	7500	C_m
Foundation and rock anchors		12500	
Moorings	34500		
Power take off	20700	5000	C_T
Contingencies	17200	12500	
	£189600 /m	£125000 /m	
Take length of device as 40km. NB. Overall length greater.			
Capital Cost of Power Station	£7584 x 10^6	£5000 x 10^6	
Capital Cost of Maintenance Base	£ 100 x 10^6	£ 20 x 10^6	
Total Capital Cost	£7684 x 10^6	£5020 x 10^6	
Annual Maintenance	£ 192 x 10^6	£ 50 x 10^6	
Annual Repayment 25 yrs 5% compound interest (Approx 7.1% simple interest)	£ 546 x 10^6	£ 356 x 10^6	
Total Annual Cost	£ 738 x 10^6	£ 406 x 10^6	

Notes:
1. Cost figures presented are preliminary figures and are intended to be used for comparison between the devices.

Table 4.2

2. POWER DELIVERED	UNITS	UPPER BOUND 95% CONFIDENCE LIMIT VALUES		LOWER BOUND 95% CONFIDENCE LIMIT VALUES	
		Floating	Bottom Standing	Floating	Bottom Standing
Average annual power delivered to Perth per m length of device	kW/m	6.8	11.5	4.0	6.5
Total annual energy delivered to Perth per m length of device (based on 24 x 365 = 8760hrs)	kWh/m	59568	100740	35040	56940
Length of Device taken as 40km					
Average annual power delivered to Perth per power station	MW	272	460	160	260
Total annual energy delivered to Perth per power station	kWh (units)	2383×10^6	4030×10^6	1402×10^6	2278×10^6
Energy cost in pence per unit	p/kWh	31.0	10.1	52.6	17.8

Notes:
1. Cost figures presented are preliminary figures and are intended to be used for comparison between the devices.